

# PATENT SPECIFICATION

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## (54) SECURITY PAPER AND DEVICE FOR CHECKING THE AUTHENTICITY OF SUCH PAPERS

(71) We, G.A.O. GESELLSCHAFT FÜR AUTOMATION UND ORGANISATION MBH, München, Euckenstr. 12, Germany, a German Body Corporate, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

The present invention relates to a method of securing a paper against forgery and determining its authenticity to a device when used in the said method for checking the authenticity of a paper and to a paper when in use in the method. By "paper", all papers or other information carriers are to be understood which represent an ideal value independently of their material value and whose imitation by unauthorized persons must be rendered as difficult as possible. Papers in this sense are bank-notes, shares, checks, deeds, identity cards, credit cards, contracts, and even works of art.

For making papers safe against forgery, it is known to provide in the paper safety features such as safety threads, watermarks, and the like, care being taken that any imitation of the safety features is possible only at a high cost, namely at a cost which would be higher than the value represented by the paper.

However, as the many forgeries, particularly of banknotes, show, it has obviously been impossible thus far to afford satisfactory safety against forgery. As investigation of the known methods and measures to secure papers against forgery has shown that, in general, these methods and measures are relatively easy to detect by the forger on the paper itself, and, thus, are relatively easy to imitate.

The invention is based on the recognition that safety against unauthorized imitation can be substantially increased if safety features can be provided in the paper which require not only a high technical, but also a high scientific expense to be analyzed. Furthermore, such authenticity features should be based on substances which, after any successful

analysis, can only be reproduced with a high expense. Thus, the substances should not be commercially available, either, so that the safety features are not rendered valueless by disclosure.

An essential feature of the present invention is that a method is provided of securing a paper against forgery and determining its authenticity in which the high technical and high scientific expense of analysing the paper results from the fact that radiations from fluorescent materials in or on the paper are analysed with apparatus which employs commercially available interference filters which have a half value width of 1.5 Angstroms. With such filters up to 10 emission lines, each for example an emission line doublet, can be separated from one another.

According to the present invention there is provided a method of securing a paper, as herein defined, against forgery and determining its authenticity in which a paper is provided showing either all over or in one or more regions thereof features provided by fluorescent materials of a particular concentration which, in the excited condition, fluoresce in the visible, ultraviolet, or infrared spectral range within characteristic emission spectra, including the authenticating step of identifying a radiation peak that occurs within a half-value bandwidth of 1.5 Angstroms.

This detailed examination of the spectra permits an unambiguous identification of the fluorescent materials to be made. Since many of these substances are colorless, they cannot be perceived with the naked eye, so that the marked points cannot be readily recognized.

For rendering any forgery difficult, a mixture of several substances, each substance fluorescing within a respective narrow spectral band is advantageously used in a given ratio to give additional safety.

For rendering any forgery difficult and thus increasing the safety factor, it is possible to mix the substances used for the authenticity check with further fluorescent substances which are not used in the authenticity check

but which emit radiation within narrow spectral ranges outside the wavelength range examined by the checking device. This does not affect the identification of the substances used for the authenticity check, but a forger will encounter difficulties because he cannot readily recognize which substances are evaluated in the authenticity check.

It is also possible to add fluorescent substances emitting light within broad spectral bands, even if they do not emit light in the spectral band examined in the authenticity check. However, the visual impression of the fluorescent color can be changed completely by adding fluorescent paints emitting light within broad spectral bands.

The invention offers the advantage that the authenticity of papers can be quickly and reliably established by an automatic checking device, e.g. in automatic money changers or vending machines, during money transactions at bank counters, when checking identity cards, etc.

Further features of the invention, including those of a device for carrying out the authenticity check according to the method will be apparent from the following description of the invention given by way of example with reference to the accompanying drawings. In the accompanying drawings, Fig. 1 shows schematically the structure of a checking device; Fig. 2 shows the geometric arrangement of a number of photocells for the identification of emission-line doublets; Fig. 3 shows the amplifier circuits for the amplification of the photocell currents; Fig. 4 shows a circuit for obtaining the difference between two photocell currents, and Fig. 5 shows a circuit for obtaining the quotient of two photocell currents.

One arrangement for use in the method for checking the safety features according to the invention essentially comprises a transfer device, which moves the paper in its plane, a light source for illuminating the paper and thus exciting the fluorescent substances, a spectrophotometer for analyzing the radiation emitted by the paper, and an electronic circuit for evaluating the photocell currents to make a decision "good" or "no good" and to trigger subsequent operations resulting therefrom.

Fig. 1 shows schematically the structure of the checking device. The paper 1 is illuminated by a light source 2. Depending on the wavelength required to excite the fluorescent substances, the light source is a high- or low-pressure gas discharge lamp, a photo-flash lamp, or an incandescent lamp. However, the fluorescence may also be excited with an X-ray tube, an electron ray tube, or a radioactive substance. If optical fluorescence excitation is used, an optical filter 3 will be disposed between the light source and the paper in order

to block interfering wavelengths in the light of the lamp.

In the particular embodiment being described, the fluorescence is in the visible spectrum and the condenser lens 4 concentrates the light emitted by the fluorescent paper and focuses it on an inclined, narrow-band interference filter 5. As is well-known, the wavelength of the maximum transmission of an interference filter is dependent on the incidence angle of the light. The more oblique the incident light the more the wavelengths of the transmitted light are shifted. The lens 6 focuses the light passed on an arrangement of similar photocells 7 in the focal plane of the lens 6. Each of the photocells is struck by monochromatic light only. Thus, each of the photocells measures the fluorescence of the paper at a different wavelength.

Fig. 2 shows a curve of light intensity on the y axis against wavelength on the x axis relative to the geometric arrangement of the photocells which is appropriately chosen in order to identify an emission-line doublet. In this arrangement, the photocells F2 and F4 measure the light emission at the wavelengths of the intensity maxima, while the photocells F1, F3, and F5 measure the brightness of the background. Thus, if a paper contains a substance having an emission spectrum as shown in Fig. 2, the photocells F2 and F4 will provide strong signals, while the photocells F1, F3, and F5 will provide no signals.

The electronic evaluation circuit for the signals is shown in Figs. 3 and 4.

In the preamplifier (Fig. 3), the photocurrents of the five photocells F1 to F5 are amplified by means of field-effect transistors T1, T2 and T4 in a straightforward manner. In order to save on components, the photocurrents of the photocells F1, F3, and F5 are added together and amplified jointly.

In the comparator (Fig. 4), the difference between the photocurrents from each of the photocells F2 and F4 fed via terminals 2 and 4 and the photocurrents from photocells F1, F3, and F5 fed via terminal 1 is developed with the aid of differential amplifiers. Thus it is possible to check whether the two intensity maxima of Fig. 2 stand out from the background. If it is the case that they do stand out, a positive voltage surge is obtained at the output A of the comparator. This output signal can be processed, in known manner, to control relays or generate audible or visual signals.

The subtraction has the added advantage that fluorescent substances which emit light and are added to the materials emitting the light to be examined within narrow bands to increase the protection against forgery do not influence the identification of the latter materials by the evaluation apparatus because the additional substances only generate, in all photocells, additional, approximately equal

photocurrents which are eliminated during the subtraction.

Fig. 5 shows a simple circuit with which not the difference but the quotient between the photocurrents of two photocells is compared with definite maximum and minimum values and used to establish the authenticity of the paper. The circuit has the advantage of affording increased safety because dirt on the paper, variations in the brightness of the lamp, and an inaccurate position of the paper in the checking device do not affect the measuring accuracy.

To permit the use of a.c. amplifiers, a light source with periodic changes of brightness is employed. In the two photocells, this results in alternating currents whose amplitudes are proportional to the fluorescence at the light wavelengths being examined (steady radiation can be processed in the same circuit with slightly more complicated d.c. amplifiers). The photocurrents of the two photocells which are applied via terminals 1 and 2 to amplifiers V1 and V2, respectively, are amplified, then rectified, and applied to the comparators K<sub>1</sub> and K<sub>2</sub>. At the potentiometers P<sub>1</sub> and P<sub>2</sub>, the permissible maximum and minimum values of the quotient between the two photocurrents are adjusted.

For a better understanding of the formation of the quotient, let the voltage-dividing ratio of the two potentiometers be designated k<sub>1</sub> and k<sub>2</sub>, respectively, and the voltages behind the rectifiers, which voltages are caused by the photocurrents, be denoted by U<sub>1</sub> and U<sub>2</sub>. If

$$U_1 < k_1 \cdot U_2$$

and

$$U_1 > k_2 \cdot U_2$$

a positive voltage is obtained at the outputs of both comparators and thus also at the output of the AND-gate G. The above relationship can also be written as

$$k_2 < \frac{U_1}{U_2} < k_1$$

Thus, a positive output signal is obtained only if the quotient of the two photocurrents lies within a tolerance which is characteristic of the paper. If no light is incident on the photocells, the voltages U<sub>1</sub> and U<sub>2</sub> are zero. In this case, a high-value resistor R ensures a small zero shift of U<sub>1</sub>, which prevents the output signal "good" from occurring in a checking apparatus without a paper.

In an analogous manner, it is possible to evaluate signals from photocell arrangements which measure two or more spectral lines.

Interference filters are commercially available which have a half-value width of 1.5 Å. With such filters, up to 10 emission lines can be separated from each other.

The device described above permits the emission of a fluorescent substance to be checked only within a relatively narrow spectral range because the dispersion element is an interference filter. A similar device may be used with the interference filter replaced by a dispersion prism or a dispersion grating. Such optical arrangements are commonly used in spectroscopes or spectrophotometers. If dispersion prisms or diffraction gratings are used in the above described arrangement, the analysis of a plurality of spectra can be carried out simultaneously with the aid of a plurality of photocells.

#### WHAT WE CLAIM IS:—

1. A method of securing a paper, as herein defined, against forgery and determining its authenticity in which a paper is provided having either all over or in one or more regions thereof features provided by fluorescent materials of a particular concentration which, in the excited condition, fluoresce in the visible, ultraviolet, or infrared spectral range within characteristic emission spectra, including the authenticating step of identifying a radiation peak that occurs within a half-value bandwidth of 1.5 Angstroms.

2. A paper when in use in a method as claimed in claim 1, the said paper having therein or thereon a first fluorescent material providing, when excited, a characteristic emission with a half-value bandwidth of 1.5 Angstroms for use in determining the authenticity of the paper and a second fluorescent material which fluoresces within either a narrow or a broad waveband which is outside the waveband which is examined in the authenticity check.

3. A paper as claimed in claim 2 wherein the second material is in a region or regions in or on the paper which is or are different from that of the first material.

4. A device when used in the method of claim 1 for detecting the emission spectra from paper as claimed in either claim 2 or claim 3, including a high-resolution spectrophotometer, and an excitation-energy source suitable for use with the said fluorescent materials.

5. A device as claimed in claim 4 wherein the spectrophotometer includes a narrow-band interference filter acting as a dispersion element.

6. A device as claimed in claim 5 or claim 6, wherein for measuring fluorescence at different wavelengths, there are provided in the spectrophotometer a plurality of photocells so that the intensity maxima and minima of the radiations emitted can each be detected by a respective photocell and the measured values can be compared with nominal values.

7. A device as claimed in claim 6, in which the measured values are the difference values between the respective maxima and minima.
- 5 8. A device as claimed in claim 6, in which the measured values are the quotient values of the respective maxima and minima, voltage dividers being provided to adjust the permissible tolerances of the quotients.
- 10 9. A paper as claimed in either claim 2 or claim 3 substantially as described herein.
10. A device when used in a method as claimed in claim 1 for detecting the emission spectra from paper, the device being substantially as described herein with reference to Figs. 1 and 2 of the accompanying drawings. 15
11. A device for detecting the emission spectra from paper as claimed in claim 5 including a circuit arrangement substantially as described herein with reference to Figs. 3 and 4 or Fig. 5 of the accompanying drawings. 20

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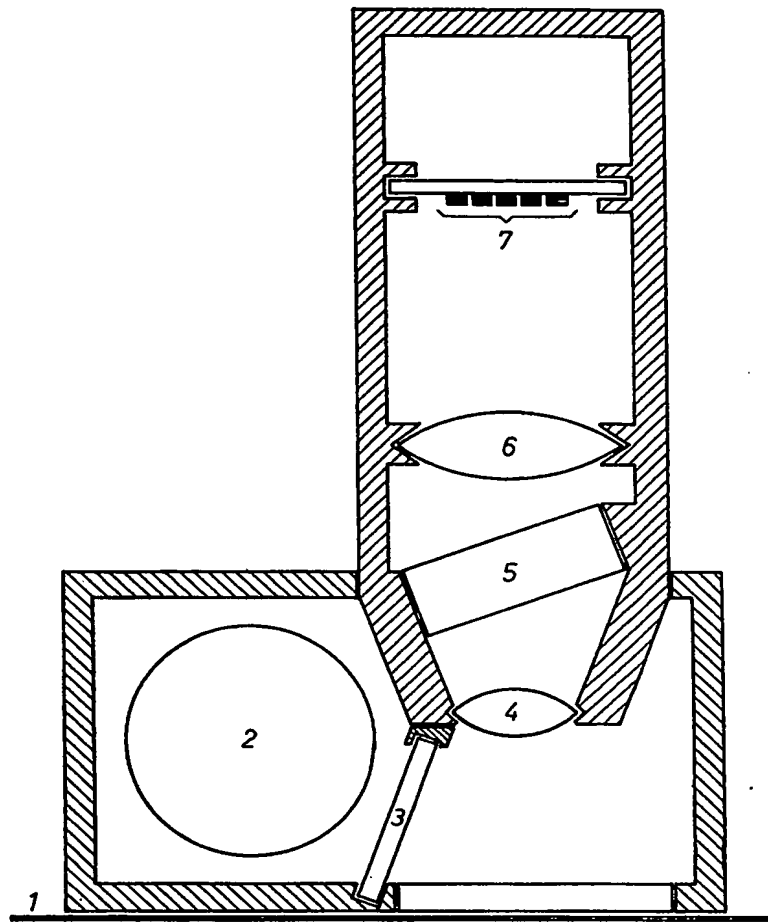
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COMPLETE SPECIFICATION

5 SHEETS

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Sheet 1



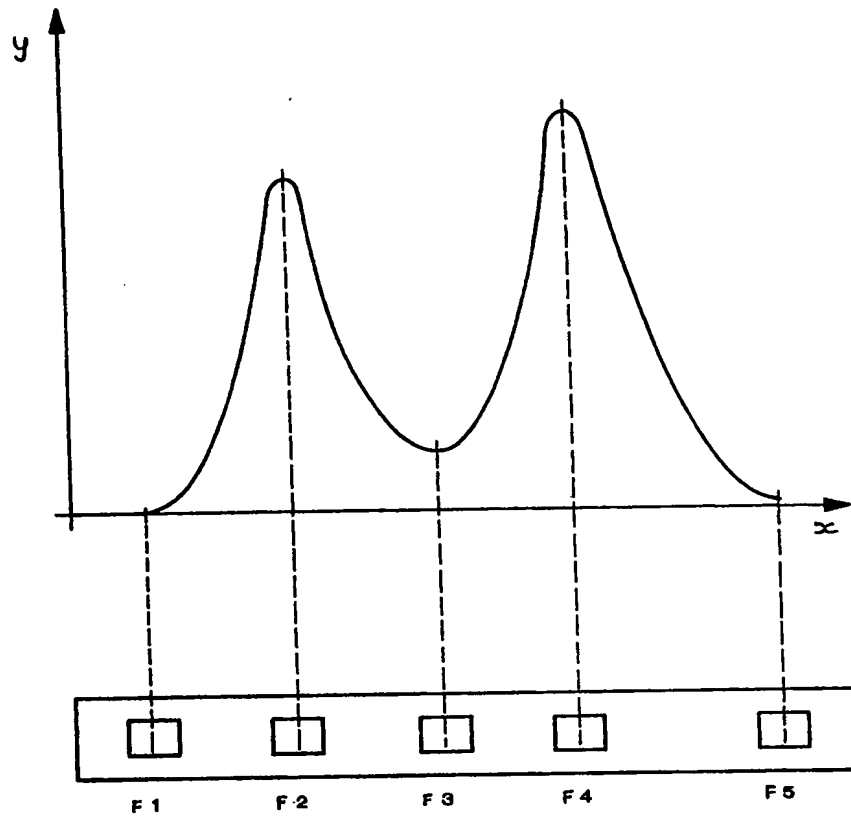
*Fig.1*

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Sheet 2*



**Fig.2**

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Sheet 3

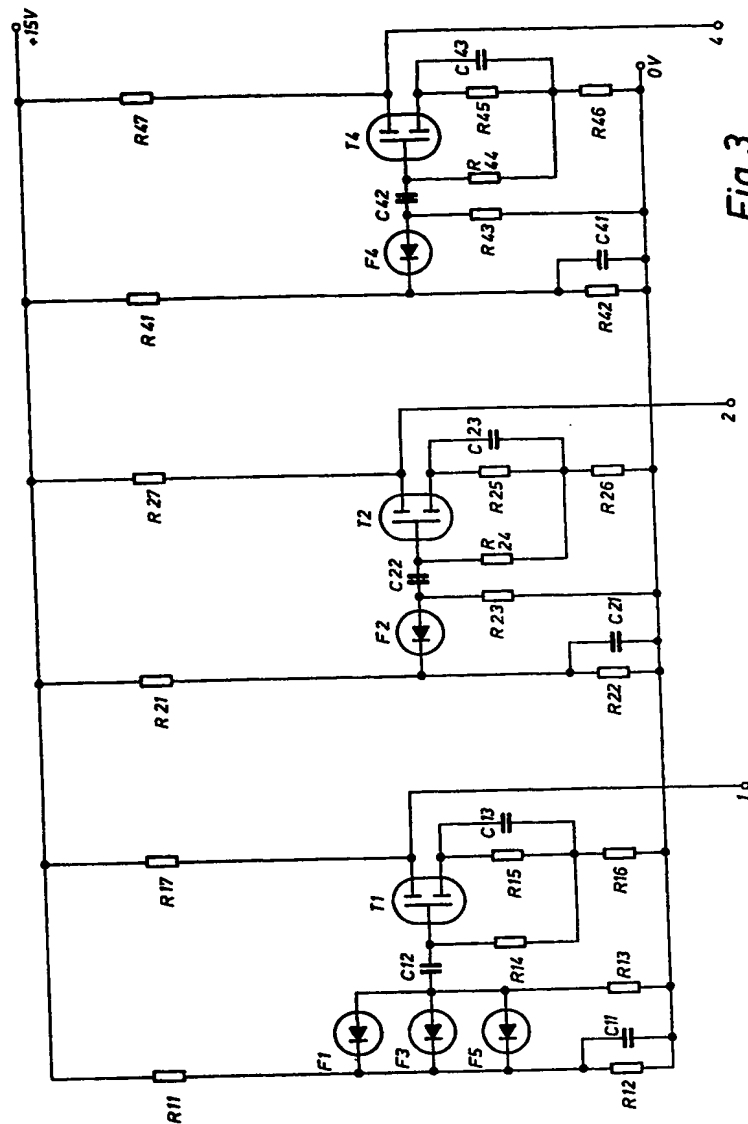


Fig. 3

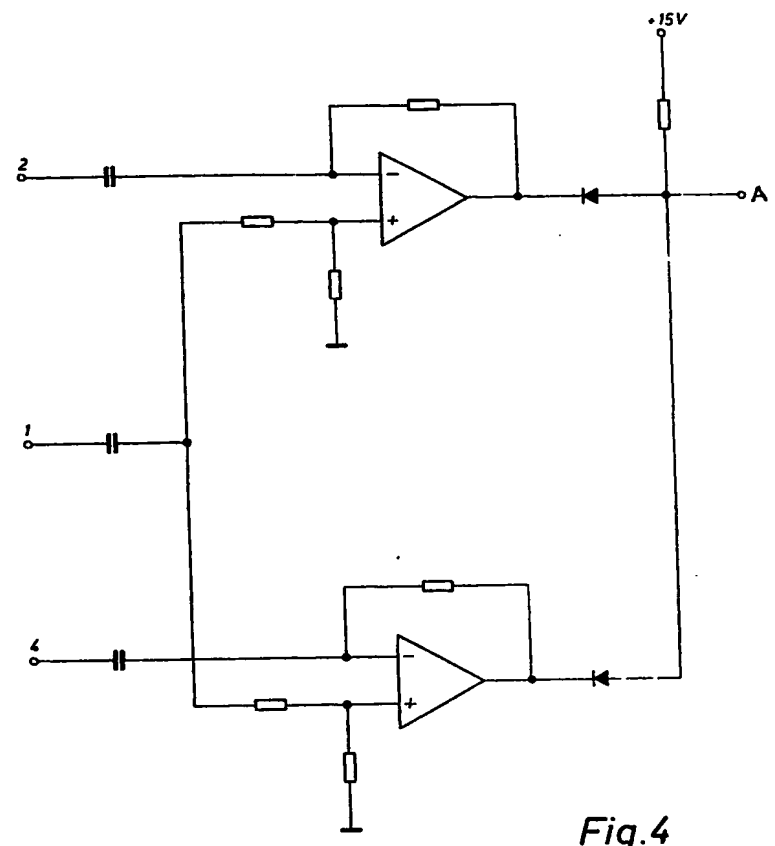


Fig.4



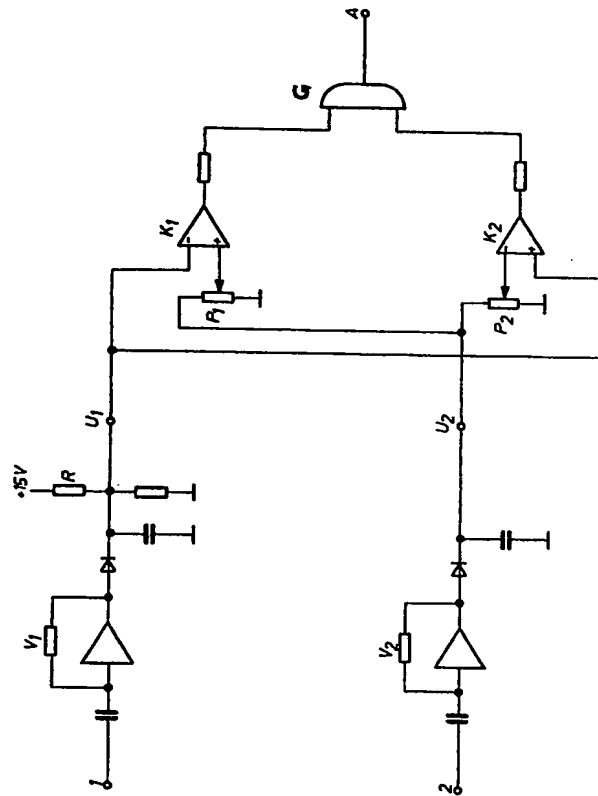


Fig. 5